LIVESTOCK ODOR STUDY COMMITTEE

NOVEMBER 28, 2007

PRESENTATION BY

DR. ROBERT T. BURNS, PE
ASSOCIATE PROFESSOR

AGRICULTURAL & BIOSYSTEMS ENGINEERING

IOWA STATE UNIVERSITY

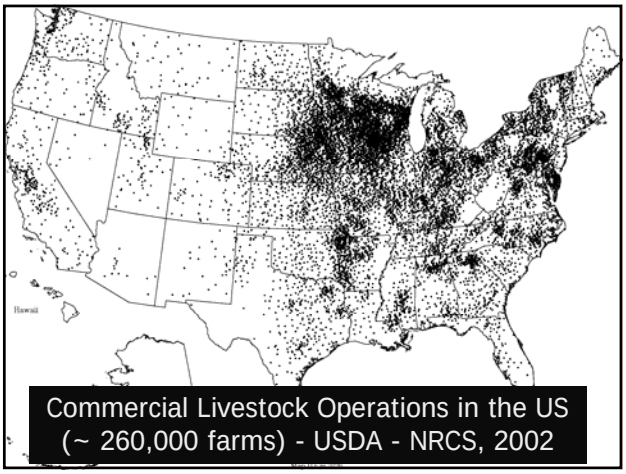
Current Status of Manure Anaerobic Digestion in the United States

Dr. Robert T. Burns, PE
Associate Professor
Agricultural & Biosystems Engineering
Iowa State University

rburns@iastate.edu

Anaerobic Digestion of Manure Provides Several Benefits

- Odor Control
- Greenhouse Gas Reduction
- Biogas Production



Commercial Livestock Operations in the US
(~ 260,000 farms) - USDA - NRCS, 2002

Current Status of Manure Anaerobic Digestion in the US

Farmers in the United States have been slow to implement manure Anaerobic Digesters

Current Status of Manure Anaerobic Digestion in the US

- It is estimated that ~ 100 manure Anaerobic Digestion systems have been built on US farms over the past 20 years
- Only 40 manure digesters are estimated to currently be operational in the US *

* Source: AgSTAR Guide to Operational Systems - http://www.epa.gov/agstar/operational.html

Success Rate of US Manure Anaerobic Digestion

- Historically the success rate of manure anaerobic digesters has been low in the US
- Lusk reported in 1998 that 50% of all installed US manure AD systems had failed (where non-operational digesters are counted as failures)

Current Numbers of US Manure Anaerobic Digesters

- The majority (73 %) of operational US manure anaerobic digesters are on dairies

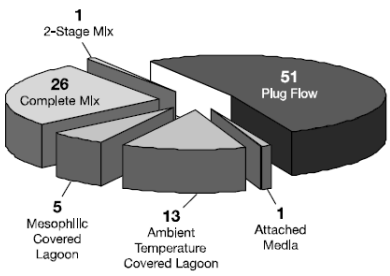
Source: AgSTAR Guide to Operational Systems - http://www.epa.gov/agstar/operational.html

Current Numbers of US Manure Anaerobic Digesters

- More than 50 additional manure digestion systems are reported to currently be planned or under construction in the US

Source: AgSTAR Guide to Operational Systems - http://www.epa.gov/agstar/operational.html

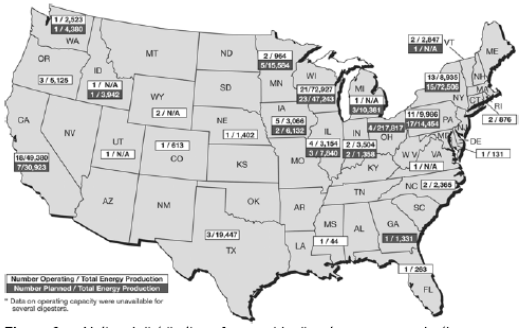
US Manure Digesters by Technology Type (Operating and Planned)



*Includes digesters in start-up and construction stage.

Source: AgSTAR Digest Winter 2006 - http://www.epa.gov/agstar/pdf/2006digest.pdf

US Distribution of Planned and Operational Manure Digesters



Source: AgSTAR Digest Winter 2006 - http://www.epa.gov/agstar/pdf/2006digest.pdf

Why are US farmers slow to implement Manure Anaerobic Digestion for energy production ?

- Low economic return from electricity generation
- Management requirements
- Lack of a well established support industry

- The cost to produce electricity using manure anaerobic digestion in the US is typically equal to or greater than the retail power rate and much greater than the US wholesale power rate.

US Retail and Wholesale Electrical Rates

- US retail electricity rates range from $ 0.04 – $ 0.14 per kWh, and average $ 0.09 per kWh
- US wholesale power rates (what the farmer is paid for electricity sold back to the utility) averages around $ 0.03 per kWh

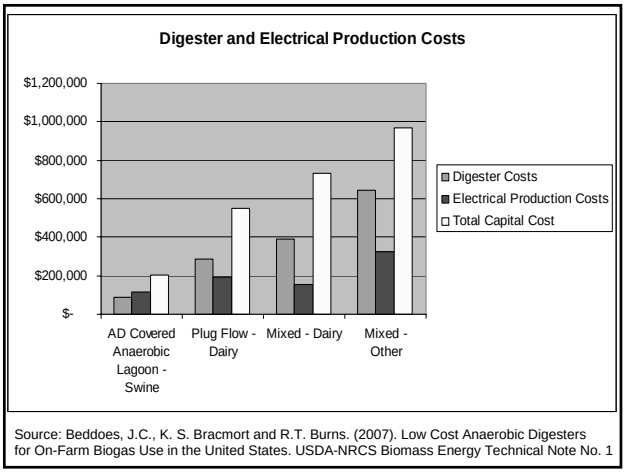
Electricity Production Costs for Case Studies with Reported Biogas Production

Manure Anaerobic Digester Type by Species	$ per GJ	$ per kWh	# of Systems
Mixed - Swine	$ 20.18	$ 0.07	2
AD - Other Swine	$ 20.18	$ 0.07	1
AD Covered Anaerobic Lagoon - Swine	$ 21.74	$ 0.08	5
Plug Flow– Dairy	$ 23.68	$ 0.09	9
Electricity – Average US Retail Costs	$ 24.05	$ 0.09	
Mixed - Dairy	$ 52.39	$ 0.19	4
AD - Other Dairy	$ 79.33	$ 0.29	1

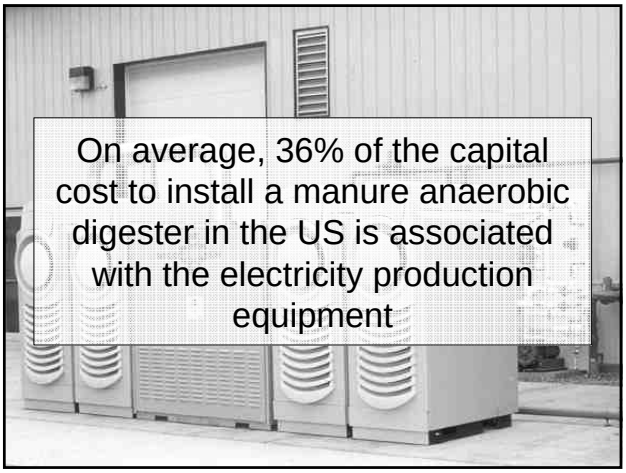
Source: Beddoes, J.C., K. S. Bracmort and R.T. Burns. (2007). An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities. USDA-NRCS Biomass Energy Technical Note No. 1

Manure AD Electrical Power Options

- Cost-Avoidance – 100% on-site use
- Net Metering – Only an option for very small digesters (~ < 100 kw) in some locations.
- Sell at the wholesale rate (typically at a loss)
- Sell power at a subsidized rate, or from an AD system where the installation costs were subsidized.



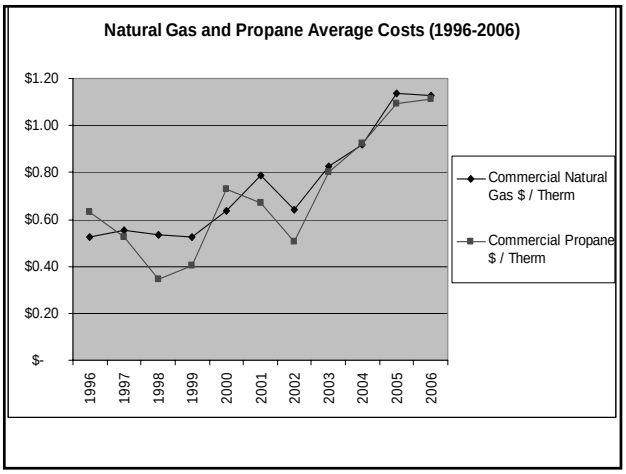
Source: Beddoes, J.C., K. S. Bracmort and R.T. Burns. (2007). Low Cost Anaerobic Digesters for On-Farm Biogas Use in the United States. USDA-NRCS Biomass Energy Technical Note No. 1

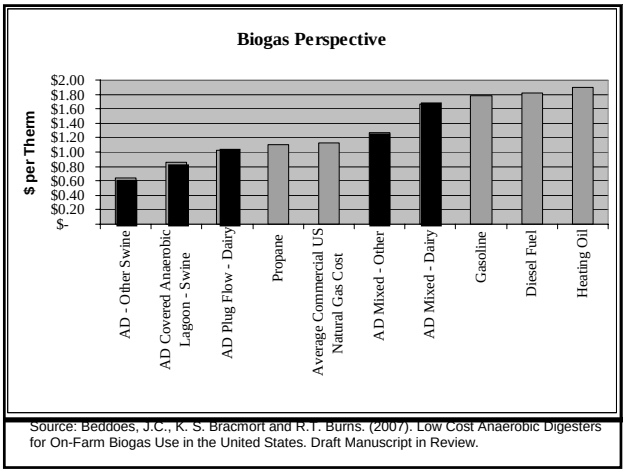


Biogas Production Costs for 38 Case Studies

Manure Anaerobic Digester Type by Species	Unit of Measurement	Cost per Unit	$ per Therm	$ per GJ	# of Systems
AD Covered Anaerobic Lagoon - Dairy	1000 cu ft	$ 1.73	$ 0.29	$ 2.72	2
AD Mixed - Swine	1000 cu ft	$ 3.84	$ 0.64	$ 6.03	2
AD - Other Swine	1000 cu ft	$ 3.85	$ 0.64	$ 6.06	1
AD Covered Anaerobic Lagoon - Swine	1000 cu ft	$ 5.19	$ 0.87	$ 8.16	6
AD Plug Flow - Dairy	1000 cu ft	$ 6.16	$ 1.03	$ 9.68	18
Propane	Gallon	$ 1.01	$ 1.11	$ 10.44	
Average Commercial US Natural Gas Cost	1000 cu ft	$ 11.60	$ 1.13	$ 10.61	
AD Mixed - Other	1000 cu ft	$ 7.64	$ 1.27	$ 12.01	2
AD Mixed - Dairy	1000 cu ft	$ 10.00	$ 1.67	$ 15.72	4
Gasoline	Gallon	$ 2.22	$ 1.78	$ 16.78	
Diesel Fuel	Gallon	$ 2.52	$ 1.82	$ 17.14	
Heating Oil	Gallon	$ 2.46	$ 1.90	$ 17.95	
AD - Other Dairy	1000 cu ft	$ 26.63	$ 4.44	$ 41.87	2

Source: Beddoes, J.C., K. S. Bracmort and R.T. Burns. (2007). Low Cost Anaerobic Digesters for On-Farm Biogas Use in the United States. USDA-NRCS Biomass Energy Technical Note No. 1





Source: Beddoes, J.C., K. S. Bracmort and R.T. Burns. (2007). Low Cost Anaerobic Digesters for On-Farm Biogas Use in the United States. Draft Manuscript in Review.

Direct Use of Biogas on US Farms

- Given current US manure biogas production costs and current US natural gas prices, the profitable use of biogas on US farms will require that the biogas either be burned as is (un-cleaned) or that very low-cost biogas cleaning technologies be used.

Biogas Cleaning Requirements

Use Category	Hydrogen Sulfide	Moisture	Carbon Dioxide
Flare	No Removal Needed	No Removal Needed	No Removal Needed
Cooking Stove	Removal Recommended	No Removal Needed	No Removal Needed
Boiler	< 1000 ppm	No Removal Needed	No Removal Needed
Heater	Removal Recommended	No Removal Needed	No Removal Needed
Stationary Engine	< 1000 ppm	No Removal Needed	Droplet Removal Required
Vehicle Engine	Removal Required	Removal Recommended	Removal Required
Sale to Pipeline	< 4 ppm	Removal Required	Removal Required

* Un-vented heaters that exhaust into habitated (animals or people) will require H_2S removal.

Manure AD Biogas Options

- Cost-Avoidance – 100% on-site use
  - Space heating, water heating, vehicle fuel
- Sale to pipeline –
  - Requires full cleaning (H_2S removal)
  - Requires full conditioning (CO_2 and H_2O removal)
  - Requires compression to pipeline pressure

For more details …..
www.abe.iastate.edu/wastemgmt/